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Voong et al.

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(54) **MITER SAW WITH ACTIVE CONTROL ENERGY DAMPENER**

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CPC ***B26D 7/24*** (2013.01); ***B23D 47/00*** (2013.01); ***F16P 3/008*** (2013.01); *B26D 1/16* (2013.01); *B27B 5/38* (2013.01); *Y10T 83/04* (2015.04); *Y10T 83/081* (2015.04)

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CPC Y10T 83/04; Y10T 83/081; Y10T 83/089; Y10T 83/088; Y10T 83/7693; Y10T 83/7697; Y10T 83/7701; Y10T 83/7705; Y10T 83/7726; Y10T 83/773; Y10T 83/8773; B25D 59/001; B25D 59/00; B25D 45/00; B25D 45/04; B27B 5/38; B27B 5/00; B27B 5/29; B26D 7/24; F16P 3/008; F16P 7/00; F16P 7/02

See application file for complete search history.

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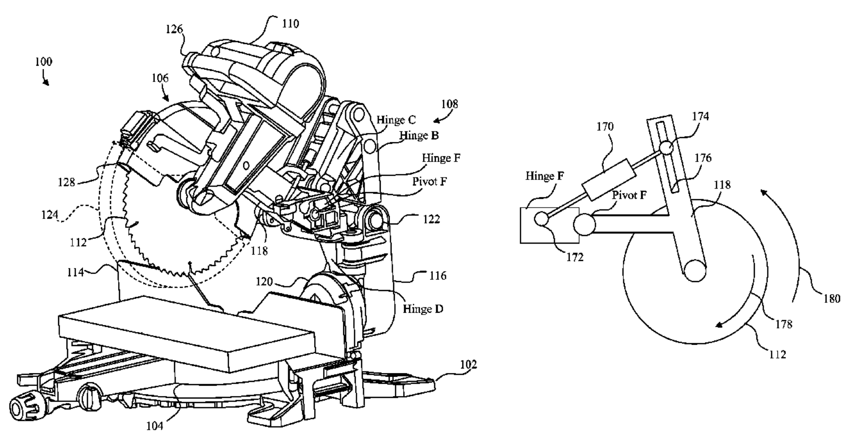
(57) **ABSTRACT**

An automatic braking system for a pivoting power tool includes a cutting assembly, a cutting arm supporting the cutting assembly, a hinge supporting the cutting arm through a pivot, a primary braking system operably connected to the cutting assembly, a safety circuit configured to sense an unsafe condition and, in response to sensing the unsafe condition, control the primary braking system to oppose rotation of a blade supported by the cutting assembly, and a damper system operably connected to the cutting arm, the damper system configured to oppose rotation of the cutting arm when the primary braking system is controlled to oppose rotation of the blade.

11 Claims, 4 Drawing Sheets



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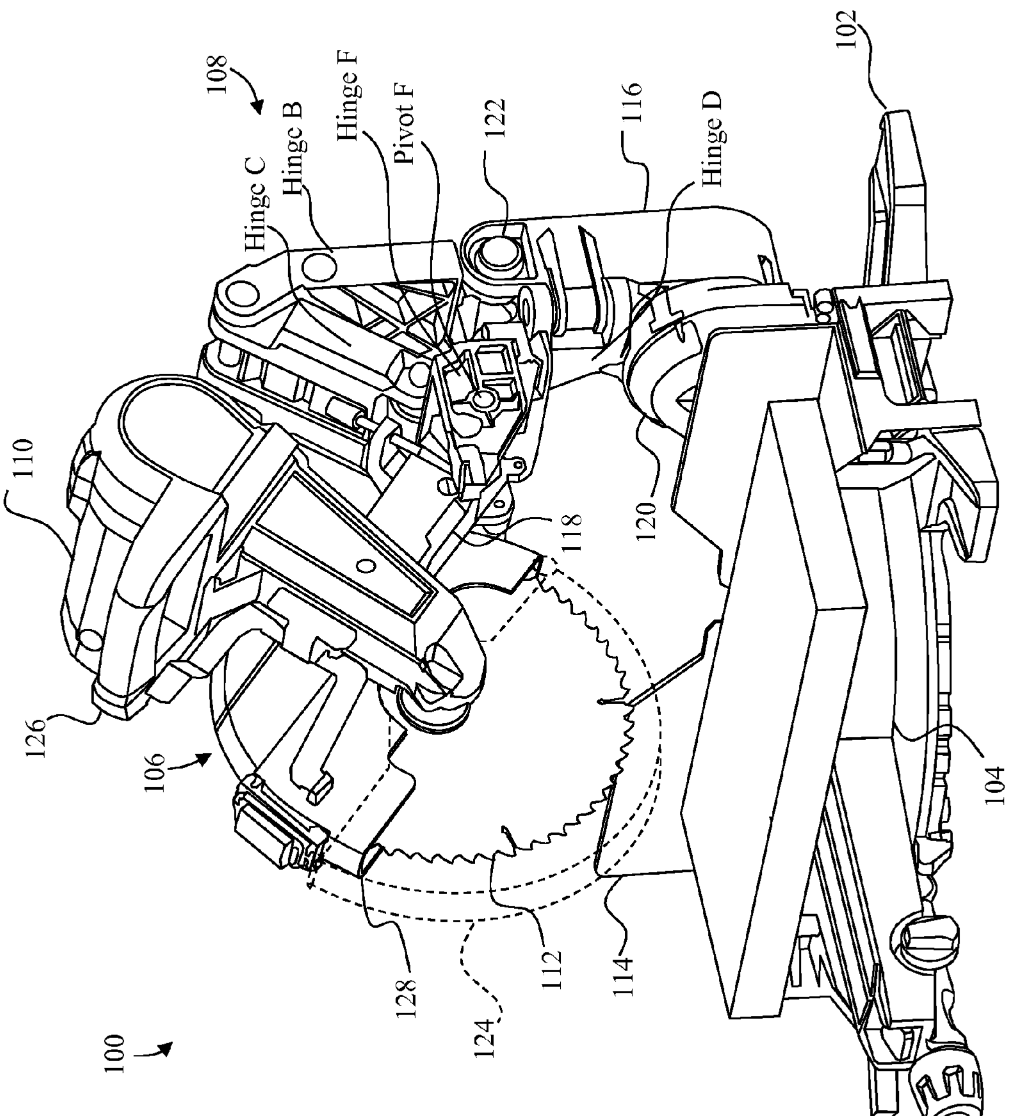


108
Hinge C
Hinge B
Hinge F
Pivot F
122
116
Hinge D
102
110
118
120
126
106
104
128
112
114
124
100

FIG. 1

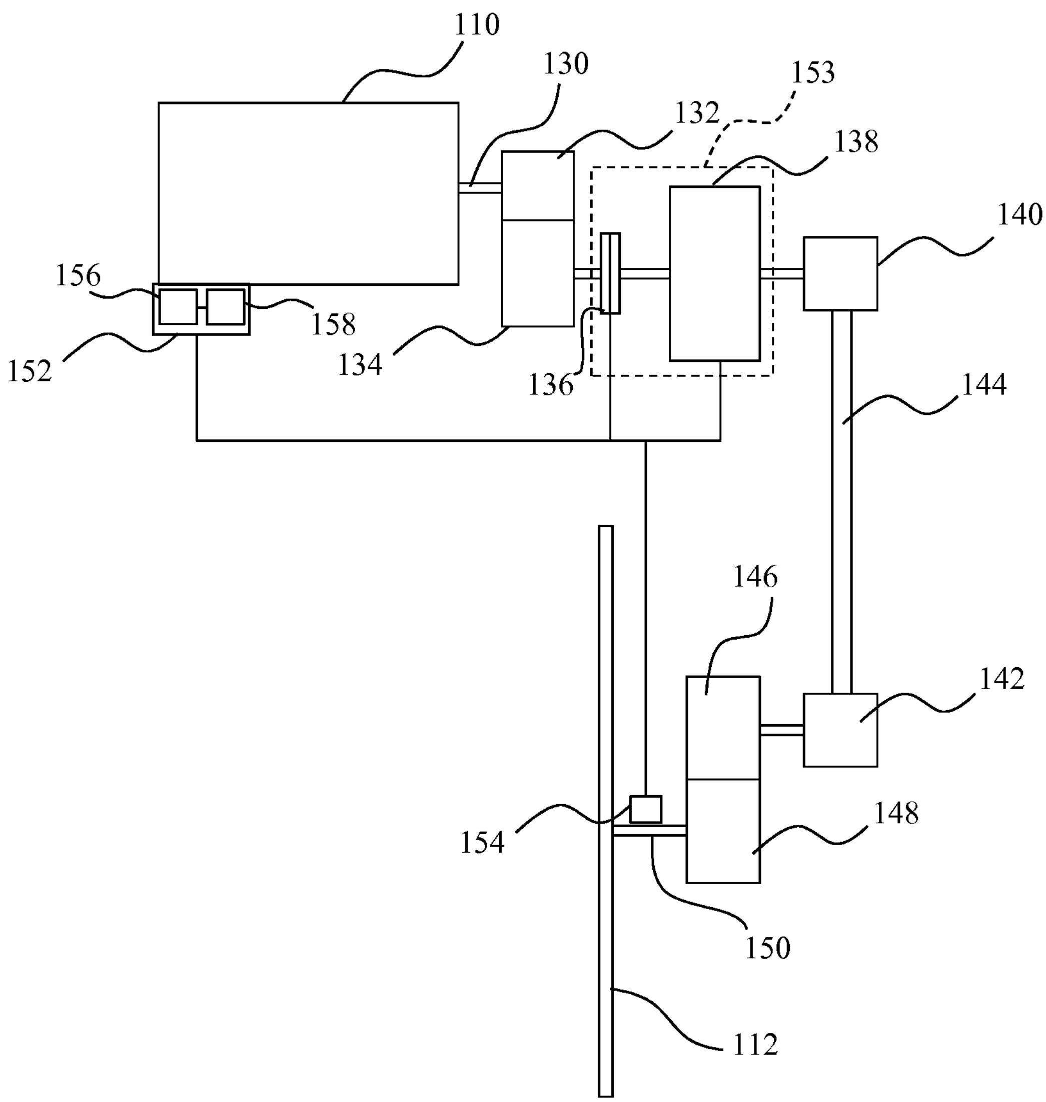

110
130
132
153
138
140
156
158
152
134
136
144
146
142
148
154
150
112

FIG. 2

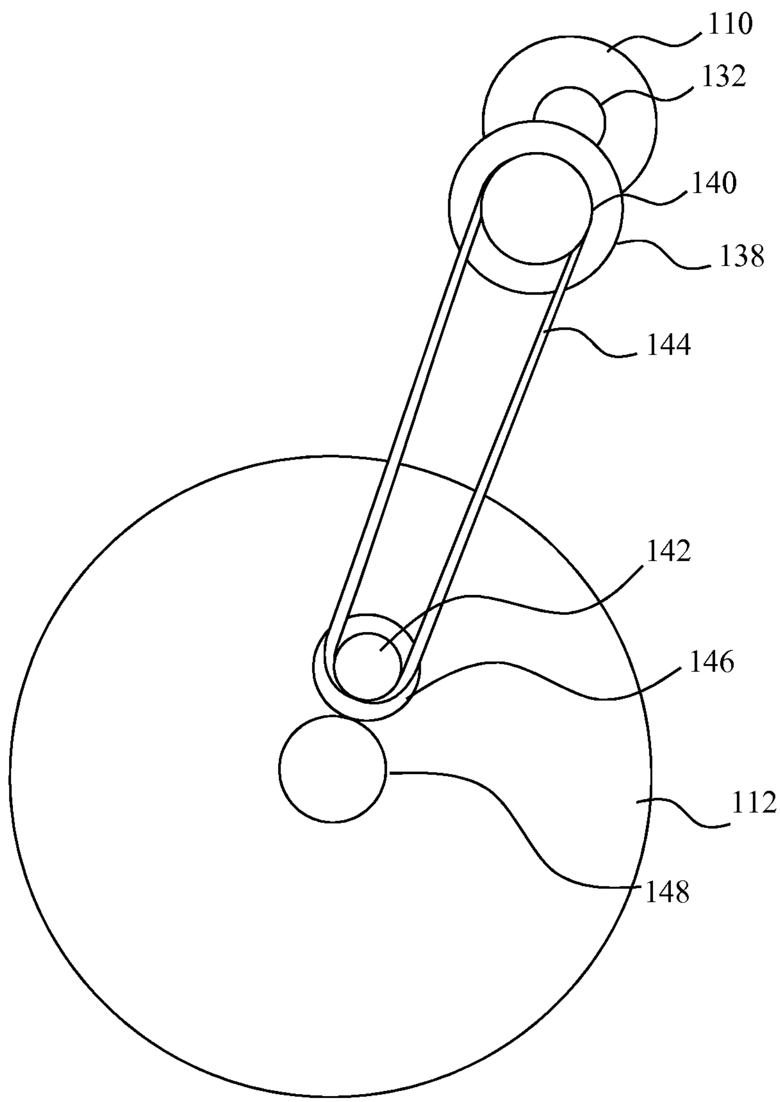
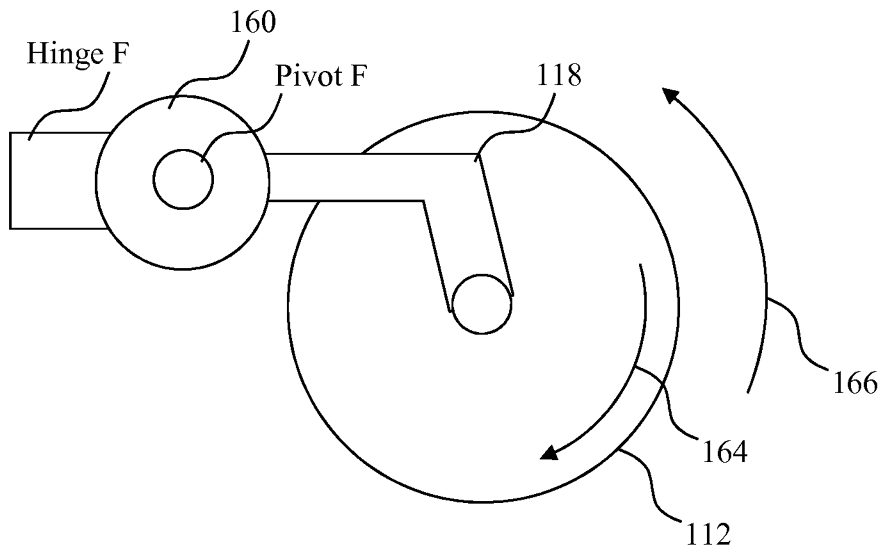
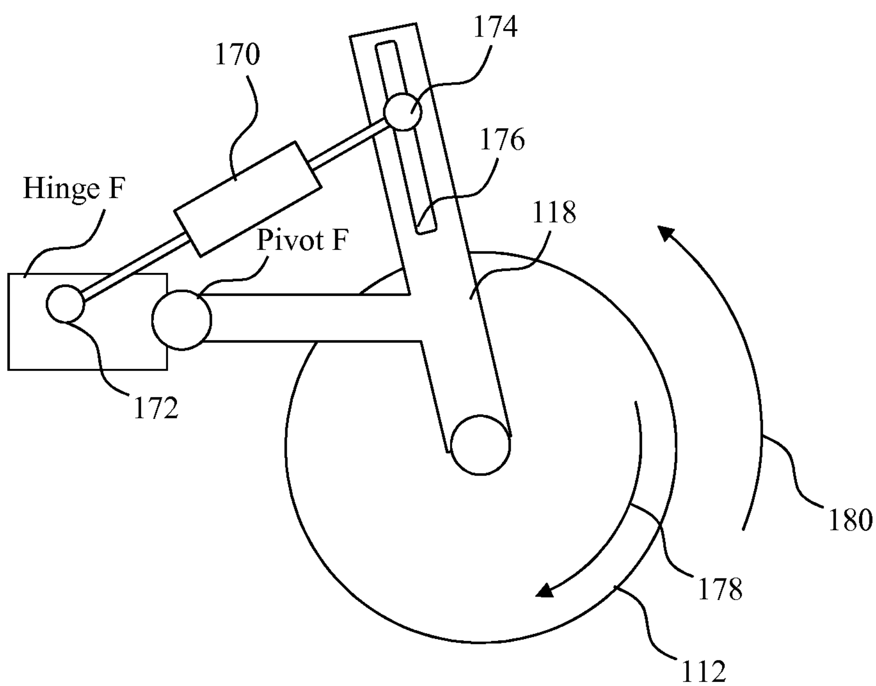


FIG. 3



160
Hinge F
Pivot F
118
166
164
112

FIG. 4



174
170
176
Hinge F
118
Pivot F
172
180
178
112

FIG. 5

MITER SAW WITH ACTIVE CONTROL ENERGY DAMPENER

This application claims the benefit of U.S. Provisional Application No. 61/781,749 filed Mar. 14, 2013, the entirety of which is incorporated herein by reference.

FIELD

This disclosure relates to machines such as miter saws which include protective systems configured to rapidly stop rotational movement of a shaping device.

BACKGROUND

A number of power tools have been produced to facilitate forming a work piece into a desired shape. One such power tool is a miter saw. Miter saws present a safety concern because the saw blade of the miter saw is typically very sharp and moving at a high rate of speed. Accordingly, severe injury such as severed digits and deep lacerations can occur almost instantaneously. A number of different safety systems have been developed for miter saws in response to the dangers inherent in an exposed blade moving at high speed. One such safety system is a blade guard. Blade guards movably enclose the saw blade, thereby providing a physical barrier that must be moved before the rotating blade is exposed. While blade guards are effective to prevent some injuries, a user's finger is nonetheless in proximity to the moving blade, particularly when attempting to secure a work piece as the miter saw is used to shape the work piece.

Miter saw safety systems have been developed which are intended to stop the blade when a user's hand approaches or touches the blade. Various stopping devices have been developed including braking devices which are physically inserted into the teeth of the blade. In general, upon detection of a person in the vicinity of the blade, a signal is processed and sent to a brake mechanism to stop blade rotation within a short period of time. One such system is disclosed in U.S. Patent Publication No. 2011/0048197. In other systems, a mechanical or electrical brake is used. In all of these systems, however, the short stopping time of the blade generates a large angular momentum that will either swing the head up or down (depending on blade or motor rotation direction for miter saws) with a high force which is destructive to the structure of the tool. In addition to posing a danger to the tool, the high angular momentum forces pose an additional injury risk to the user.

What is needed therefore is a simple and reliable configuration which reduces the potential for transferring high angular momentum forces to a tool thereby causing movement of the tool.

SUMMARY

In one embodiment, an automatic braking system for a pivoting power tool includes a cutting assembly, a cutting arm supporting the cutting assembly, a hinge supporting the cutting arm through a pivot, a primary braking system operably connected to the cutting assembly, a safety circuit configured to sense an unsafe condition and, in response to sensing the unsafe condition, control the primary braking system to oppose rotation of a blade supported by the cutting assembly, and a damper system operably connected to the cutting arm, the damper system configured to oppose rotation of the cutting arm when the primary braking system is controlled to oppose rotation of the blade.

In another embodiment, a method of operating an automatic braking system for a pivoting power tool includes supporting a cutting assembly with a cutting arm, sensing an unsafe condition using a safety circuit, controlling with the safety circuit a primary braking system to oppose rotation of a blade supported by the cutting assembly in response to sensing the unsafe condition, and opposing with a damper system rotation of the cutting arm about a pivot when the primary braking system is controlled to oppose rotation of the blade.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a front right perspective view of a miter saw assembly;

FIG. **2** depicts a schematic diagram of the power transfer train between the motor and the blade including a clutch and a primary braking system;

FIG. **3** depicts a simplified plan view of the right side of the power transfer train;

FIG. **4** depicts a simplified left side plan view of a hydraulic torsional dampener located at the pivot between the cutter arm and bevel arm; and

FIG. **5** depicts a simplified left side plan view of a hydraulic linear dampener extending between the cutter arm and bevel arm.

DESCRIPTION

For the purposes of promoting an understanding of the principles of the disclosure, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that no limitation to the scope of the disclosure is thereby intended. It is further understood that the present disclosure includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the disclosure as would normally occur to one skilled in the art to which this disclosure pertains.

Referring now to FIG. **1**, there is shown a miter saw assembly **100**. The miter saw assembly **100** includes a base **102** and a turntable **104** that is rotatable on the base **102**. The miter saw assembly **100** further includes a cutting head **106** mounted on a cutting head support assembly **108**. The cutting head **106** (which may also be referred to herein as a "cutting assembly") includes a motor **110** that is operable to rotate a circular saw blade **112**. The cutting head support assembly **108** is attached to the turntable **104** and configured to support the cutting head **106** such that the cutting head **106** may move over the turntable **104** and perform cutting operations on a work piece supported by the turntable **104**. A rip fence **114** attached to the base **102** may be used to align a work piece thereon.

The cutting head support assembly **108** includes a bevel arm **116**, a cutting arm **118**, a first pivot mechanism **120**, and a second pivot mechanism **122**. The bevel arm **116** (also referred to herein as a "bevel post") provides a bevel support structure for the miter saw assembly **100**. The bevel arm **116** is pivotally attached to the turntable **104** by the first pivot mechanism **120**. The first pivot mechanism **120** includes a hinge arrangement that enables the bevel arm **116** of the support assembly **108** to pivot with respect to the turntable **104** during a setup procedure. In particular, this arrangement is configured to enable the bevel arm **116** to pivot from a vertical position (as shown in FIGS. **1-2**) to an angle of 45° (not shown) or more in the leftward direction prior to a cutting operation. This pivoting allows the blade **112** of the cutting assembly **106** to approach the table **104** from a bevel angle and perform angled cuts on a work piece supported on the table **104**, as is well known in the art.

The cutting arm **118** of the support assembly **108** provides a support for the cutting assembly **106**. The cutting arm **118** is pivotably connected to the bevel arm **116** via the pivot mechanism **122**. The pivot mechanism **122** enables pivoting movement of the cutting assembly **106** in relation to the turntable **104** and the base **102** during a cutting operation. This pivoting allows the blade **112** of the cutting assembly **106** to move toward and away from the horizontal turntable **104** to perform a cutting operation. In some embodiments, the cutting arm may be configured to alternatively or additionally allow movement of the cutting assembly along the cutting arm.

The cutting assembly **106** includes a handle **126** connected to the cutting arm **118** to facilitate movement of the cutting assembly **106** in relation to the turntable **104**. The handle **126** is designed and dimensioned to be grasped by a human hand when performing a cutting operation. This allows the user to easily pivot the cutting assembly **106**. A switch (not shown) may be provided on the handle **126** to allow the user to easily energize and de-energize the electric motor **110** during a cutting operation. A blade guard **128** covers the top portion of the circular saw blade **112**. A lower blade guard **124**, shown in shadow for purpose of clarity, is rotatably mounted to the cutting head assembly **106**. The lower blade guard **124** is configured to rotate in a clockwise direction with respect to the cutting head assembly **106** when the cutting head assembly **106** is pivoted toward the turntable **104** thereby exposing the circular saw blade **112**.

The connection between the motor **110** and the saw blade **112** is further described with reference to FIGS. **2** and **3**. The motor **110** has an output shaft **130** which drives a pinion gear **132**. The pinion gear **132** is operably connected to a gear **134** that drives a clutch assembly **136**. The output of the clutch assembly **136** is operably engaged with a primary braking assembly **138**. The primary braking assembly **138** in one embodiment is the braking assembly described in U.S. Patent Application Publication No. 2011/0048197, the entire contents of which are herein incorporated by reference.

The primary braking assembly **138** drives a pulley **140** which is operably connected to a pulley **142** by a belt **144**. In some embodiments, the pulley system is replaced by a geared drive system. The pulley **142** is operably connected to a gear **146** which drives a gear **148** operable connected to a drive shaft **150** on which the blade **112** is mounted. The motor **110**, along with the gears and pulleys, are configured such that the blade **112** rotates downwardly at a location farthest from the bevel arm **116**.

FIG. **2** further shows a safety circuit **152** that is operably connected to the clutch assembly **136**, the primary braking assembly **138**, and a blade sensor **154** (located adjacent to the drive shaft **150** in this embodiment). The safety circuit **152** includes a processor **156** and a memory **158**. Program instructions within the memory **158** are executed by the processor **156** to perform at least some of the actions ascribed to the safety circuit herein. The safety circuit **152** detects when a user too closely approaches or touches the blade **112** and issues a signal which disengages the clutch **136** and activates the primary braking assembly **138** to rapidly stop as discussed in more detail in the '197 Publication.

The safety circuit **152** is further connected to a dampener which in this embodiment is a hydraulic torsional dampener **160** (see FIG. **4**). The torsional dampener **160** is located at the pivot **122** between the cutting arm **118** and the bevel arm **116** and is activated at about the same time as the primary braking assembly **138**. Accordingly, as the rotation of the blade **112** in the direction of the arrow **164** (see FIG. **4**) is terminated by the

primary braking assembly **138**, a large angular momentum in the direction of the arrow **166** is generated which forces the cutting arm **118** to pivot about the pivot **122** in the direction of the arrow **166**. The hydraulic torsional dampener **160**, however, counters the large angular momentum, thereby reducing any movement of the cutting arm **118** in the direction of the arrow **166**. The active dampening system which includes the dampener **160** is thus configured to reduce the destructive force that could transfer to the structure of the tool or to the hand of the end user. This dampening system makes the braking of the blade in a short time possible for miter saws without undesired "kickback" of the cutting arm **118**.

In some embodiments, the torsional dampener is replaced with a linear dampener. FIG. **5** depicts a linear dampener **170** with a first end **172** pivotably attached to the bevel arm **116** and a second end **174** positioned within a slot **176** in the cutting arm **118**. Accordingly, as the rotation of the blade **112** in the direction of the arrow is terminated by the primary braking assembly **138** in the manner described above, a large angular momentum in the direction of the arrow **180** is generated which forces the cutting arm **118** to pivot about the pivot **122** in the direction of the arrow **180**. The hydraulic linear dampener **170**, however, is activated and at the same time the end portion **174** is locked within the slot **176** by the safety circuit **152**. The linear dampener **170** thus counters the large angular momentum, thereby reducing any movement of the cutting arm **118** in the direction of the arrow **180**.

The incorporation of a dampener such as the hydraulic torsional dampener **160** or the linear dampener **170** reduces output force to the structure of a power tool to enable for braking within a predetermined time to mitigate potential injuries. The dampening system enables control of a power tool such as miter saw head assemblies.

The described system in different embodiments is configured as a torsional or linear form and can be configured between the bevel arm and cutting arm (as shown in above figures or in similar configurations).

The described dampening system in some embodiments is activated using the angular acceleration of the cutting arm through mechanisms similar to that of an automotive seatbelt or other mechanical means. In other embodiments, a dampening system is activated using an electromechanical system. In some embodiments, activation of the dampening system is accomplished by locking an end of the dampener which is free to move during normal saw operation.

The above described system in some embodiments is used with a mechanical brake similar to that described in the '197 Application and is sized accordingly based on moment inertia of the blade and other rotation components the blade is connected to.

In some embodiments, the primary brake is a mechanical brake such as an aluminum block that makes contact with the blade teeth, or any friction material that makes contact with the blade walls, output shafts, or any drive mechanism. In some embodiments, the primary brake is an electronic brake generated within the motor assembly.

In different embodiments, the output force reduction occurs immediately after flesh detection or after flesh detection plus a predetermined time.

While the disclosure has been illustrated and described in detail in the drawings and foregoing description, the same should be considered as illustrative and not restrictive in character. It is understood that only the preferred embodiments have been presented and that all changes, modifications and further applications that come within the spirit of the disclosure are desired to be protected.

The invention claimed is:

1. A method of operating an automatic braking system for a pivoting power tool, comprising:

supporting a cutting assembly with a cutting arm;

sensing an unsafe condition using a safety circuit;

controlling with the safety circuit a primary braking system to oppose rotation of a blade supported by the cutting assembly in response to sensing the unsafe condition;

opposing with a damper system rotation of the cutting arm about a pivot when the primary braking system is controlled to oppose rotation of the blade; and

controlling the damper system comprising controlling a linear damper operably connected to the cutting arm and to a bevel post supporting the cutting arm;

wherein the cutting arm includes a slot and the linear damper is pivotably attached to the bevel post at a first end portion and includes a second end portion positioned within the slot, and wherein controlling the linear damper comprises locking the second end portion within the slot.

2. The method of claim **1**, wherein opposing with a damper system comprises:

activating the damper system by angular acceleration of the cutting arm.

3. The method of claim **1**, wherein opposing with a damper system comprises:

controlling the damper system with the safety circuit in response to sensing the unsafe condition.

4. The method of claim of claim **3**, further comprising:

disengaging with the safety circuit a primary clutch through which the primary braking assembly is operably connected to a motor in response to sensing the unsafe condition.

5. The method of claim **4** further comprising:

rotating the blade with the motor through a pulley operably connected to the primary clutch prior to sensing the unsafe condition.

6. The method of claim **3**, wherein controlling with the safety circuit the primary braking system to oppose rotation of the blade occurs substantially simultaneously with controlling with the safety circuit the damper system.

7. An automatic braking system for a pivoting power tool, comprising:

a cutting assembly;

a cutting arm supporting the cutting assembly;

a hinge supporting the cutting arm through a pivot;

a primary braking system operably connected to the cutting assembly;

a safety circuit configured to sense an unsafe condition and, in response to sensing the unsafe condition, control the primary braking system to oppose rotation of a blade supported by the cutting assembly; and

a damper system operably connected to the cutting arm, the damper system configured to oppose rotation of the cutting arm when the primary braking system is controlled to oppose rotation of the blade;

wherein the damper system comprises a linear damper operably connected to the cutting arm and to a bevel post supporting the cutting arm;

wherein the cutting arm includes a slot and the linear damper is pivotably attached to the bevel post at a first end portion and includes a second end portion positioned within the slot; and

wherein activation of the damper system comprises locking the second end portion within the slot.

8. The automatic braking system of claim **7**, wherein the damper system is activated by angular acceleration of the cutting arm.

9. The automatic braking system of claim **7**, wherein the safety circuit is further configured to activate the damper system in response to sensing the unsafe condition.

10. The automatic braking system of claim **9**, wherein:

the primary braking assembly is operably connected to a motor through a primary clutch; and

the safety circuit is configured to disengage the primary clutch in response to sensing the unsafe condition.

11. The automatic braking system of claim **10**, wherein:

the primary braking assembly is operably positioned between the primary clutch and a pulley, the pulley operably connected to the blade.

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